Electrical and optical characteristics of an atmospheric pressure direct barrier discharge plasma jet

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I. Introduction

A DBD plasma jet, which works under atmospheric pressure, has been developed for fundamental investigation of plasma chemistry and applications such as modification and surface treatment of polymers. The plasma is generated with a dielectric barrier discharge and a process gas (He or Ar) which flowing out into environment air. The DBD plasma jet features a cold gas temperature [1][2]. In this work electrical and optical characteristics of an atmospheric pressure plasma jet generated at 70 kHz frequency in Ar, He and theirs mixtures with water vapor is investigated.

II. Experimental set up

In this investigation a DBD jet was generated in a quartz capillary with inside and outside diameter of 1.3 and 3.0 mm, respectively. Figure 1, shows a schematic of our system consisting of two electrodes, in which insulated with a dielectric material from quartz capillary in form of a tube. The high voltage electrode is a wire of 0.5 mm diameter. The electrode is made of tungsten and placed inside the quartz capillary. The ground electrode in form of a ring (length of 10 mm) is placed around the capillary on 40 mm distance from the tip of high voltage electrode. By flowing gas through the tube between these two electrodes the plasma is generated.

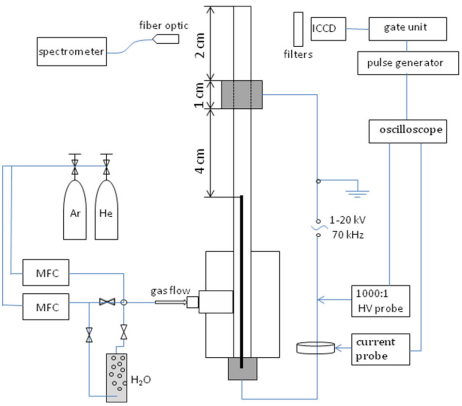

Figure 1 schematic of the plasma set-up

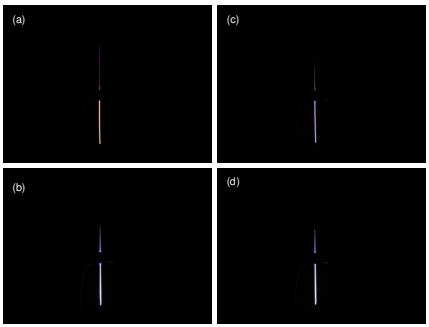

Figure 2 images of the discharge: (a): pure He, (b):pure Ar, (c):He/H_2O, (d):Ar/H_2O

Figure 2 shows a series of images of the DBD jet in He, He/H_2O, Ar and Ar/H_2O

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mixtures. All of the images were taken at the same magnification, distance and resolution

III. ELECTRICAL CHARACTERISTICS

The electrical performance of the discharge has also been studied for He, He/H_2O, Ar, Ar/H_2O mixtures as a function of voltage, power, initial gas flow and water vapor concentration in inlet gas by means of voltage and current probes.

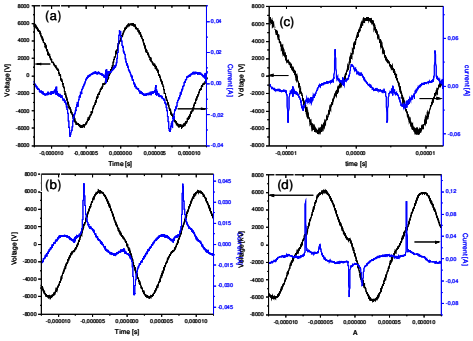

Figure 3. Voltage/current of the discharge generated in (a): He, (b): Ar, (c): He/H_2O, (d): Ar/H_2O

As it shown in Figure 3, increase of water concentration in gas phase results to decrease of the input power and change to asymmetry behavior of the current waveform on positive and negative half period of the applied voltage.

IV. OPTICAL EMISSION SPECTROSCOPY

Axial optical emission spectroscopy of the jet afterglow has been applied for characterization of the afterglow and investigation of water content influence on plasma system.

The study of He, He/H_2O, Ar, Ar/H_2O mixtures by OES is of great interest of the DBD plasma jet for applications such as modification and treatment of polymers. In Figure 4, the typical spectra in the range of 200-900 nm are presented for Ar, Ar/H_2O mixtures with the 0.05% and 0.7% of the H_2O.

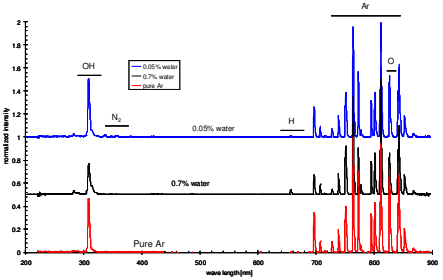

Figure 4 optical emission spectra of Ar and Ar/H_2O mixtures at the fixed applied voltage 12.2 kV

Among the different band detected, apart from the most intensive line of Ar in 763 nm, and OH band at 308 nm, the other most important features correspond to the species emission band located at 777.4 nm and 844 nm (O^I line), 656.3 nm (H_α line) and 310-440 nm (N_2, N_2^+ bands).

V. CONCLUSION

The electrical and optical characterization of a DBD plasma jet source shows that a high concentration of OH radicals are formed inside the plasma which can be used for different applications such as treatment of polymers.

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REFERENCES

[1] M. Laroussi, T. Akan, "Arc-free atmospheric pressure cold plasma jets: a review", plasma process and polymers, 4, 777, 2007

[2] J. L. Walsh, J.J. Shi, M.G. Kong, "Contrasting characteristics of pulsed and sinusoidal cold atmospheric plasma jets", App. Phys. Lett, 88, 171501, 2006.